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Study of the FSO System and its Affecting Factors

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Abstract
In this paper, Wireless communication technology has been discussed with new technology, namely Free Space Optics (FSO). In first part of report consist of the introduction of FSO System. The second chapter includes all history of FSO. It follows the basic concept of FSO, working of FSO, its advantages and limitations. In the third chapter the designing factor of FSO is discuss.

Keywords: *FSO system, Scintillation, Turbulence, Fog, EYE safety.*

INTRODUCTION

In recent year, the use of free space optics is developing rapidly compared to other transmission. FSO is one kind of wireless optical communication. It required 100% wline of site. But different atmospheric problems reduce the efficiency of FSO. We use LED as transmitter in FSU and we can use different types of photo detector in FSO. FSO technology is very simple compare to other system. The bandwidth of optical is very much higher than wireless communication. AS FSO technology requires no spectrum licensing, its project cost is very much low. Many more advantage are also become reason for FSO system's popularity.

FSO SYSTEM

FSO system's history

Historically, Free Space Optics (FSO) or optical wireless communications was first demonstrated (in primary phase) by the lighthouse of Alexandria [1]. For architects, it meant even more: it was the tallest building on Earth. And for scientists, it was the mysterious mirror that fascinated them most. The mirror's reflection could be seen more than 50 km (35 miles) off-shore. The carrier of the message in this system is light.

Next example is, the Photo phone invented by Alexander Graham Bell in the late nineteenth century (prior to his demonstration of the telephone!).

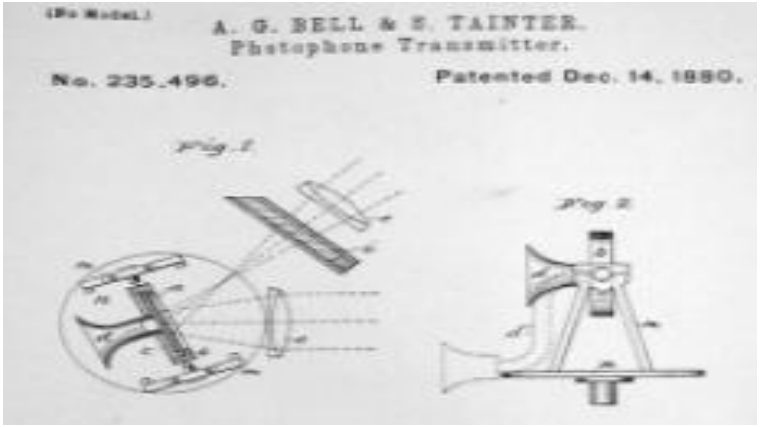

Fig: 1. *Design of Bell's Photo phone [1]*

It works of the principle of BELLs phone.

Need of FSO system

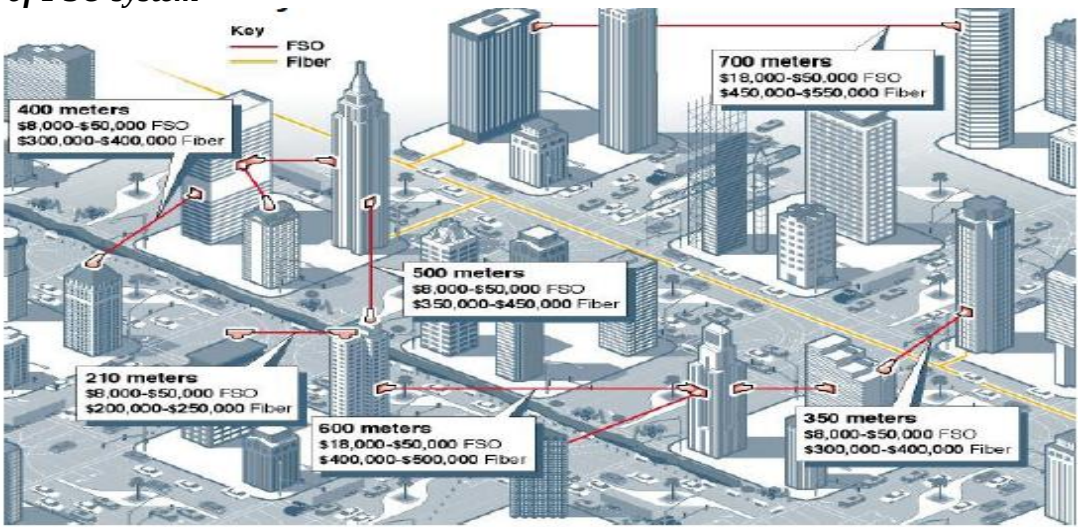

Fig: 2. *FSO vs. Fiber connectivity in metro [1]*

The need of FSO increase day by day. AT&T use FSO as communication media. More companies require high bandwidth but it is very much expensive, in this type of situation laying a fiber cable is a very difficult task. So, there is a need of new type of wireless communication technique, which has same data rate as optical fiber cable. Free space optical communication is the solution of this problem.

Working flow of FSO system

Figure 1 in free space optical communication. Invisible light is used for the communication. Laser will generate light and electrical signal is converting into light signal in Laser. This light will travel through the atmosphere. But during travelling it should deal with different type of atmospheric obstacle.

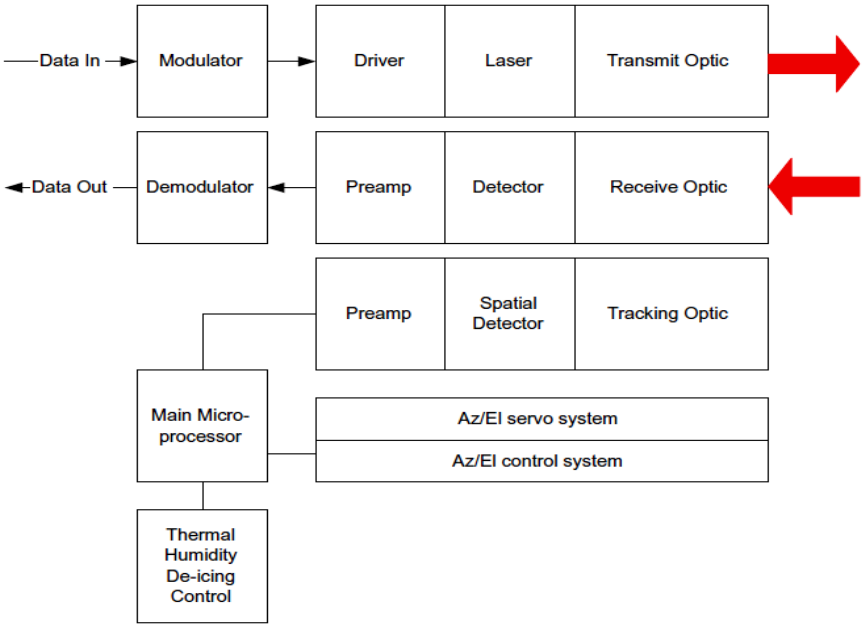

Fig: 3. *FSO Major Sub-system [2]*

In figure 3, the transmit, receive, and tracking telescopes are illustrated as separate optical apertures; there are several other configurations possible where, for example, a single optic performs all three functions thereby saving cost, weight, and size.

The coupling system is very similar for fiber lasers because the core of the fiber laser and the output aperture of a Fabry-Perot laser have similar sizes [3]. The distance between the input and output should be calculated. According to distance and power to be transmitted, we should take laser and photodiode as a input and output source. The use of special materials or controls is required in this case; however, coupling is more modular.

Avalanche photodiode and PIN diode can use as receiver. We use APD most of the case, as it induce low loss and we can get more SNR for this receiver.

The FSO Link Equation

With help of transmitted power, receiver aperture cross section, distance between input and output source, we can calculated the received power with help of below equation.

$$P_{received} = P_{transmit} * \left(\frac{A_{receiver}}{(Div * Range)^2}\right) * \exp\text{^}(-\propto * \text{Range})$$

With help of equation we can say that we can control transmitted power, receiver aperture, distance between input and output source. But we cannot control atmospheric loss as it is naturally induced. As discussed in a later section, this implies the link range must be less than 500 m. However, efficient designs can be produced that permit economical, reliable operation under this constraint.

ADVANTAGE, LIMITATION AND SOME IMPLEMENTATION OF FSO

ADVANTAGE OF FSO

Advantages of FSO

High bit rate (10 Mbps to 2.5 Gbps)

- No licensing required
- Installation cost is very low as compared to laying Fiber
- Easy to install
- Narrow light beam
- Highly secure transmission possible
- The lasers used are eye safe, so even a butterfly can fly unscathed through a beam
- It is very much safe as it cannot detect by any kind of spectrum analyzer as it is infrared and invisible light transmission.

Limitation of FSO

- Here we are using air as a medium. So performance is highly dependent on environment. So, if the environment is not good our data rate is limited. We have to design our model carefully based on the environmental condition of the particular place.
- Line of sight is necessary. So, if there is an obstruction is there between transmitter and receiver this setup cannot be established. To avoid this, we have to set this on the roof of the tall buildings.
- Comparing with optical fiber, its range is very much limited, which also is dependent on environmental condition. So we can use this only for LAN or MAN. We cannot use this in overseas condition.
- As with any laser, eye safety is a concern. Two range of wavelength are used for FSO transmission. They are 1500nm and 800nm.800nm wavelength is not safe for eye as retina absorb this wavelength so we generally use 1550 nm wavelength as it is safe for our eyes. Some Application of FSO

Here some applications of newly developed FSO system are discuss below:

- 'Last-Mile' Network Solutions
- Temporary Network Provision
- CCTV Security Applications

- Communication in satellite
- Industry and University area.
- LAN-to-LAN connections on campuses at Fast Ethernet or Gigabit Ethernet speeds

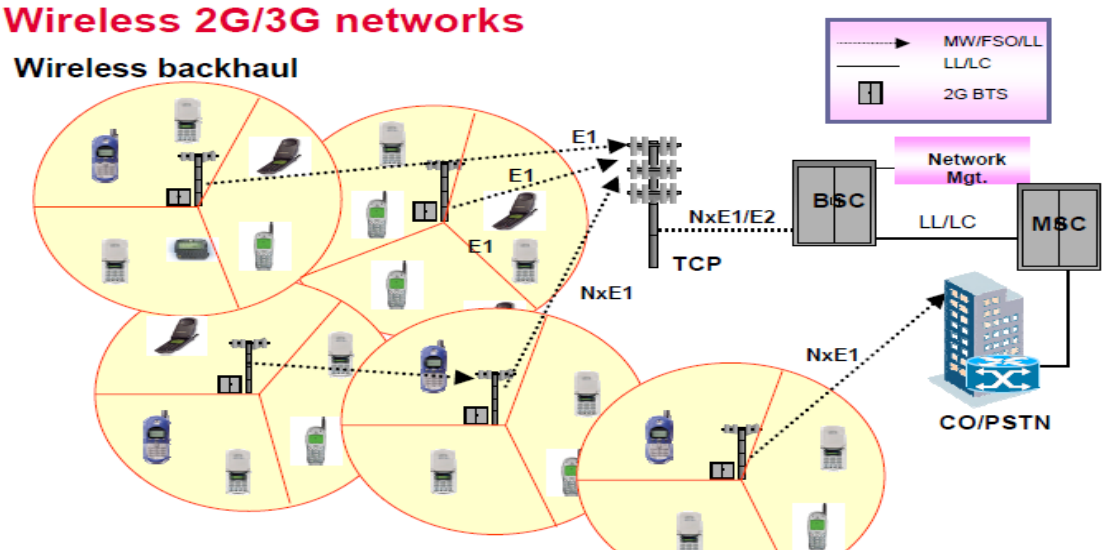

Fig: 4. *Setup of wireless 2G/3G network with use of FSO as backhaul [1]*

Data Transmission Limitation

There are three major factors that limit the data rate of an optical wireless system: (1) ambient light, (2) multipath distortion (in the case of non-LOS links), and (3) the response time of the opto-electronic components used for the transmitter and the receiver. The solar power reaching the photo-detector of an optical wireless system can be several orders of magnitude larger than the maximum power emitted by the transmitter and saturate the detector.

Moreover, the laser diodes (LDs) used at the transmitter relies in many cases on a relatively large area monitor photodiode that controls and stabilizes the LD output power through its current. These LDs can have their operation affected if their monitor photodiode (which is sometimes located at the back of the laser diode) is exposed to solar energy. Indoor communication suffers multipath dispersion. So it is one of the reason of reduce output data. Outdoor communication suffers from atmospheric loss. Current Implementation:

New York City Mercantile Exchange

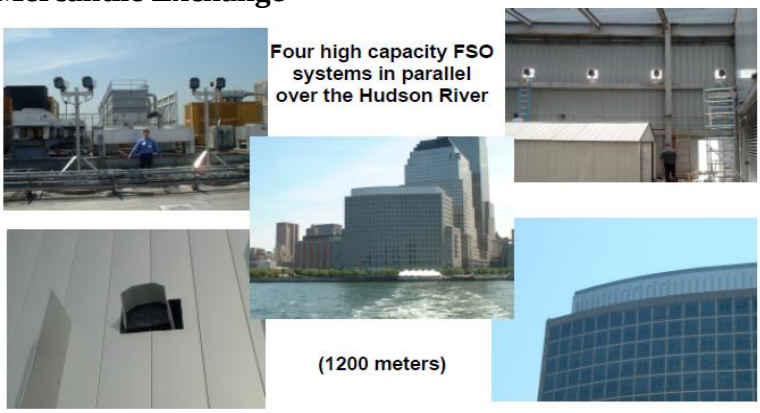

Fig: 5. *Setup of FSO units in New York City Mercantile Exchange*

Ida Test Bed in Singapore

Fig: 6. *Setup of FSO units in iDA test bed in Singapore*

DESIGNING FACTOR OF FSO

FSO is useful device for the fast communication. In FSO there is scattering loss and absorption loss.

Wavelength Selection

Currently available free space optical communication use 1550nm wavelength. To select the best wavelength we should consider absorption loss, scattering loss etc. Mie scattering is more for IR signal so it should be consider.

Eye Safety

Laser beams with wavelengths in the range of 400 to 1400 nm emit light that passes through the cornea and lens and is focused onto a tiny spot on the retina while wavelengths above 1400 nm are absorbed by the cornea and lens, and do not focus onto the retina[3]Atmospheric Turbulence.

Some atmospheric turbulence is discussed in this section.

Physical Obstraction

Birds are the major obstruction for the free space optical communication. So the birds have impact on free space optical communication. FOS Line of sight are the major disadvantage of FSO.

Visibility

Because of low visibility we cannot get the correct way of the communication in FSO. Examples are fog across a river or pond or an air conditioner‘s exhaust stream on top of a roof. Another solution is to use a multiple beam system to maintain higher link availability.

Distance

FSO cover less distance due to atmospheric loss. More distance more loss occurs in the free space communication.

Turbulence

FSO system should be installing above the roof top so that we can reduce turbulence loss as turbulence increase with altitude.

A great deal of work was done on this topic for applications like telescope signals and earth-satellite links, where a majority of the scintillation could be observed near the Earth‘s surface.

We can write the variance equation,

$$\sigma_i^2 = 1.23 C_n^2 k^{\frac{7}{6}} L^{\frac{11}{6}}$$

Scattering

In the FSO communication light have to travel from different obstacles. There is

different type of loss in FSO communication. In scattering, the intensity of light will not reduce like absorption loss. But direction of light will change. We get low output then desire output.

CONCLUSION

FSO will become advance communication medium in nearby future. In this type of communication environment condition plays an important role in transmission setup. For this atmospheric problem many solution is available.

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